

REMARKS/ARGUMENTS

Reexamination and reconsideration of this application as amended is requested. By this amendment, Claims 1-3, 10-12, 18-20 and 29, have been amended. After this amendment, Claims 1-29 remain pending in this application.

Drawing Objections

(1) The Examiner objected to FIGs. 4, 9A-9B, 11, and 12, for various informalities including hand-drawn labels, captions, diagrams, and charts. Applicant has submitted herewith twelve sheets of formal drawings with all sheets being labeled "Replacement Sheet". In the submitted formal drawings, Applicant has amended FIGs. 4, 9A-9B, 11, and 12, to correct the various informalities indicated by the Examiner, and Applicant believes that the objection has been overcome. Applicant requests that the Examiner withdraw the objection to the drawings.

Claim Objections

(2) The Examiner has objected to Claim 29 because of a minor informality. Applicant has amended Claim 29 to replace "wxw" with " $\omega x\omega$ " to correct the very minor informality and not for patentability or to further limit the claim in view of any prior art. Applicant therefore believes that the objection to Claim 29 has been overcome. In view of the amendment and remarks above, Applicant kindly requests that the Examiner withdraw the objection to Claim 29.

Claim Rejections - 35 USC § 112

(3-7) The Examiner rejected Claims 2-3, 11, and 19-20 under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention.

Applicant has amended Claims 2 and 19 to more clearly and affirmatively recite the present invention. Dependent Claims 3 and 20, that depend from Claims 2 and 19, were amended to conform to the amendments of respective claims 2 and 19. Applicant specifically has deleted the following language from amended Claims 2 and 19:

“determining a multiple-view correspondence between the plurality of detected image pixels in the first image and the plurality of detected image pixels in the at least a second image, the multiple-view correspondence being a refinement of the first two-view correspondence, resulting in a second potential match set of candidate image pixels between the first image and the at least a second image, wherein the second potential match set is based at least in part on a computation of reprojection error for matched pixels that resulted from a projective reconstruction of the second potential match set”.

Further, Applicant has amended the respective claim language for these claims to refer to a first multiple-view potential match set and to a second multiple-view potential match set. This now more clearly and definitely recites the new and novel features of the presently claimed invention. For example, amended Claim 2 now more clearly and distinctly recites “[a] potential **two-view** match set of candidate image pixels between the first image and the one of the at least a second image; **concatenating a plurality of two-view match sets to form a first multiple-view potential match set; and determining a second multiple-view potential match set that is a refinement of the first multiple-view potential match set**”. (**Emphasis added**). Support for these amendments may be found in the specification as originally filed. See generally the section beginning on page 12 of the Specification, and also see paragraphs [0031]-[0058] of U.S. Patent Application Publication No. 2002/0172413 A1, the teachings of which being incorporated by reference into the present patent application. No new matter was added by the amendment.

Applicant believes that in view of the amendment and remarks above the rejection of Claims 2-3 and 19-20 under 35 U.S.C. 112, second paragraph, has been overcome. Applicant kindly requests that the Examiner withdraw the rejection of Claims 2-3 and 19-20.

Additionally, Applicant has amended Claim 10 to more clearly and affirmatively recite the present invention. Amended Claim 10 more clearly and affirmatively recites "a second image window of the same pre-determined size in one of at least one reference view". Therefore, Claim 10 now provides proper antecedent basis for amended Claim 11. Support for these amendments may be found in the specification as originally filed, see for example page 13, lines 3-5 and 10-13, and page 29, lines 15-16. No new matter was added by the amendment.

Applicant has amended Claim 11 to more clearly and affirmatively recite the present invention. Amended Claim 11 more clearly and affirmatively recites "rectification of at least one pair of images corresponding to the base view of the scene and one of the at least one reference view". See for example page 13, lines 3-5 and 10-13, and page 29, lines 15-16. No new matter was added

In view of the amendment to Claims 2-3, 10-11, and 19-20, and the remarks above, Applicant believes that the rejection of Claims 2-3, 11, and 19-20, under 35 U.S.C. § 112, second paragraph, as discussed above, has been overcome. Applicant respectfully requests that the Examiner withdraw the rejection of Claims 2-3, 11, and 19-20.

(8-10) The Examiner rejected Claim 29 under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement.

Applicant has amended the Specification at page 4, line 15 in conformance to the language already found in Claim 29 to include "In Equation (7) the E_g is calculated using finite difference calculations." No new matter was added.

Further, “finite difference” as an approximation to derivatives is a well known term for those of ordinary skill in the art. For example, “The ability to expand smooth functions in Taylor series allows the values of derivatives to be approximated, rather than calculated analytically.” See Philip E. Gill et al., Practical Optimization, Page 54, Academic Press; attached hereto as Exhibit 1. Also, please refer to the following URL, <http://mathworld.wolfram.com/FiniteDifference.html>, as further evidence of the above.

In view of the amendment to the specification and the remarks above, Applicant believes that the rejection of Claim 29 under 35 U.S.C. § 112, first paragraph, has been overcome. Applicant requests that the Examiner withdraw the rejection of Claim 29.

Claim Rejections - 35 USC § 102

(11-26) The Examiner rejected Claims 1, 4-9, 12-18, and 21-26 under 35 U.S.C. 102(b) as being anticipated by Chen and Medioni, “A Volumetric Stereo Matching Method: Application to Image-Based Modeling” IEEE 1999. This rejection is respectfully traversed.

Applicant has amended independent Claims 1 and 18 to more clearly and distinctly recite the present invention. Applicant has amended Claims 1 and 18 specifically to more clearly recite “wherein the first view is one of **at least three views of a scene**”; “a plurality of images, each image representing one of the at least three views of the scene, wherein each of the at least three views of the scene **are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other**”. Amended Claim 12 recites similar claim language. Support for these amendments may be found in the specification and drawings as originally filed. For example, see FIG. 3; and see the specification, on page 7, lines 5-13. No new matter was added by the amendment.

Chen [VSMM99] teaches a volumetric stereo matching method that is applied to image-based modeling. Two cameras, which are not parallel, are used to take the stereo images.

However, Chen [VSMM99] teaches that the task of rectification is to numerically align the two image planes so that they are coplanar and their scanlines are horizontally coincident.

In contrast, as now recited for amended Claims 1 and 18, and similarly for amended Claim 11, the presently claimed invention recites detecting a plurality of pixels in a base image that represents a first view of a scene. The first view is one of at least three views of a scene. A 3-D depth of the plurality of pixels in the base image is determined by matching correspondence to a plurality of pixels in a plurality of images. Each image represents one of the at least three views of the scene that are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other. The present invention further recites tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the plurality of images. As a result, the virtual piecewise continuous depth surface viewed from the base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image is created.

The present invention, as now recited for amended Claim 12, similarly recites the above claim language with respect to the “views of a scene” and the arrangement and orientation of the views of the scene.

Chen [VSMM99] does not teach, anticipate, or suggest, at least three views of a scene nor does the reference teach that each image represents one of the at least three views of the scene that are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other. In fact, Chen [VSMM99] teaches that images taken by **two** cameras are numerically aligned so that the images are **coplanar** and their **scanlines are horizontally coincident** in order to perform the method as taught by Chen [VSMM99]. See Chen [VSMM99] page 30 under the heading 2 (Image Rectification).

On the other hand, the present invention as recited by amended Claims 1, 12, and 18, may perform the method as recited on images that are non-parallel and non-linear. Therefore, in view

of the amendments and remarks above, Applicant believes that since Chen [VSMM99] does not teach, anticipate, or suggest, *inter alia*, the presently claimed “at least three views of a scene”, and further does not teach, anticipate, or suggest, the presently claimed “each image represents one of the at least three views of the scene that are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other”, the rejection of Claims 1, 12 and 18, under 35 U.S.C. 102(b) as being anticipated by Chen [VSMM99] has been overcome. The Examiner should withdraw the rejection of these claims.

Claims 4-9, 13-17, and 21-26, depend from Claims 1, 12, and 18, respectively, either directly or by way of an intervening claim, and since dependent claims recite all of the limitations of the independent claim; it is believed that, therefore, claims 4-9, 13-17, and 21-26 also recite in allowable form. Therefore, Applicant believes that the rejection of Claims 4-9, 13-17, and 21-26, under 35 U.S.C. 102(b) as being anticipated by Chen [VSMM99] has also been overcome. The Examiner should withdraw the rejection of these claims.

Claim Rejections - 35 USC § 103

(27-30) The Examiner rejected Claims 27-28 under 35 U.S.C. 103(a) as being unpatentable over Chen and Medioni, “A Volumetric Stereo Matching Method: Application to Image-Based Modeling” IEEE 1999. This rejection is respectfully traversed.

Claims 27-28 depend from amended Claim 18. The above arguments and remarks regarding Claims 1 and 18, and more specifically with respect to the claim language

“detecting a plurality of pixels in a base image that represents a first view of a scene, wherein the first view is **one of at least three views of a scene**; determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in a plurality of images, **each image representing one of the at least three views of the scene, wherein each of the at least three views of the scene are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other**”,

are likewise applicable here in support of the allowability of dependent Claims 27-28. These applicable arguments have already been presented above and will not be repeated here.

Accordingly, in view of the amendments and remarks above, since Chen [VSMM99] does not teach, anticipate, or suggest, the presently claimed invention as recited for amended Claim 18, and for dependent Claims 26-27, Applicant believes that the rejection of Claims 27-28 under 35 U.S.C. 103(a) has been overcome. The Examiner should withdraw the rejection of these claims.

(31-39) The Examiner rejected Claims 2-3 and 19-20 under 35 U.S.C. 103(a) as being unpatentable over Chen and Medioni, “A Volumetric Stereo Matching Method: Application to Image-Based Modeling” IEEE 1999 in view of Zhang, Deriche, Faugeras, and Luong, “A Robust Technique for Matching Two Uncalibrated Images Through the Recovery of Unknown Epipolar Geometry”, INRIA 1994). This rejection is respectfully traversed.

Applicant has amended Claims 2 and 19 to more clearly and distinctly recite the present invention. Amended Claim 2, as representative for these amended claims, more clearly and distinctly recites “[a] potential **two-view** match set of candidate image pixels between the first image and the one of the at least a second image; **concatenating a plurality of two-view match sets to form a first multiple-view potential match set; and determining a second multiple-view potential match set that is a refinement of the first multiple-view potential match set**”. Support for these amendments may be found in the specification as originally filed. See generally the section beginning on page 12 of the Specification, and also see paragraphs [0031]-[0058] of U.S. Patent Application Publication No. 2002/0172413 A1 that are incorporated by reference in the present patent application. No new matter was added by this amendment.

First of all, Claims 2-3, and 19-20 depend from amended independent Claims 1 and 18, respectively, and as discussed above, since dependent claims recite all of the limitations of the independent claim, it is believed that, therefore, Claims 2-3 and 19-20 are not taught, anticipated, or suggested by the teachings of Chen [VSMM99]. Additional arguments regarding the allowability of Claims 2-3, and 19-20 are given below.

As discussed above, Chen [VSMM9] teaches a volumetric stereo matching method that is applied to image-based modeling using two non-parallel cameras. The images being numerically aligned so that the images are coplanar and their scanlines are horizontally coincident.

Zhang teaches a robust technique for matching two uncalibrated images through the recovery of the unknown epipolar geometry. The Examiner directs Applicant to Section 6.3 on pages 16-19 of Zhang, wherein Zhang teaches a stereo matching method. Additionally, Zhang teaches that outliers will severely affect the precision of the fundamental Matrix taught by Zhang. Therefore, possible outliers should be taken into account in the initial correspondences.

In contrast, as recited for amended Claims 2 and 19, the presently claimed invention detects a plurality of image pixels in a first image corresponding to a first view of a scene. A plurality of image pixels in at least a second image corresponding to a respective at least a second view of the scene is detected. The at least a second image deviates from the first image as a result of camera relative motion. A first two-view correspondence between the plurality of detected image pixels in the first image and a plurality of detected image pixels in one of the at least a second image is determined and results in a potential **two-view** match set of candidate image pixels between the first image and the one of the at least a second image. **A plurality of two-view match sets is concatenated to form a first multiple-view potential match set and a second multiple-view potential match set that is a refinement of the first multiple-view potential match set is determined.**

Chen [VSMM99] does not teach, anticipate, or suggest, “a plurality of two-view match sets is concatenated to form a first multiple-view potential match set and a second multiple-view potential match set that is a refinement of the first multiple-view potential match set is determined”. As stated above, Chen [VSMM99] teaches two cameras, and therefore, two views of an image. See the Chen [VSMM99] specification, for example, on page 30, Section 2. Therefore, Chen [VSMM99] does not teach or suggest the present invention, as now recited for amended Claims 2 and 19.

Turning now to Zhang, Zhang also does not teach, anticipate, or suggest “a plurality of two-view match sets is concatenated to form a first multiple-view potential match set and a second multiple-view potential match set that is a refinement of the first multiple-view potential match set is determined”. In fact, Zhang explicitly teaches two views of an image. See for example page 6, Section 3, and FIG. 1.

Furthermore, Zhang does not teach or suggest at least three views of a scene nor does the reference teach or suggest that each image represents one of the at least three views of the scene that are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other. See for example FIG. 1. Therefore, Zhang does not teach or suggest the presently claimed invention as recited for amended Claims 2 and 19, or for amended Claims 1 and 18 from which Claims 2 and 19 depend.

Applicant has amended Claims 3 and 20 to conform to the amendments of amended Claims 2 and 19, from which Claims 3 and 20 depend. Amended Claims 3 and 20 more clearly and distinctly recites “wherein the second multiple-view potential match set is based at least in part on a least median of squares computation of the reprojection errors related to matched pixels in the first multiple-view potential match set.”

The above arguments and remarks regarding Chen [VSMM99] and Zhang with respect to Claims 2 and 19, and more specifically, a “first multiple-view potential match set” and a “second mulitple-view potential match set”, are likewise applicable here in support of the allowability of Claims 3 and 20.

Accordingly, in view of the amendments and remarks above, since neither Chen [VSMM99], Zhang, nor any combination thereof, teaches, anticipates, or suggests, the presently claimed invention as recited for amended Claims 2-3 and 19-20, Applicant believes that the rejection of Claim 2-3 and 19-20 under 35 U.S.C. 103(a) has been overcome. The Examiner should withdraw the rejection of these claims.

(40-45) The Examiner rejected Claims 10-11 under 35 U.S.C. 103(a) as being unpatentable over Chen and Medioni, “A Volumetric Stereo Matching Method: Application to Image-Based Modeling” IEEE 19999 in view of Okutomi and Kanade, “A Multiple-Baseline Stereo”, IEEE 1993 in further view of Lewis, “Fast normalized Cross-Correlation”, 1995. This rejection is respectfully traversed.

First of all, Claims 10-11 depend from amended independent Claim 1 by way of an intervening claim, and as discussed above, since dependent claims recite all of the limitations of the independent claim, it is believed that, therefore, Claim 1 and its dependent Claims 10-11 are not taught, anticipated, or suggested by the teachings of Chen [VSMM99]. Additional arguments regarding the allowability of Claims 10-11 are given below.

Okutomi teaches a stereo matching method that uses multiple stereo pairs with various baselines to obtain precise distance estimates without suffering from ambiguity. The Examiner directs Applicant to the Abstract, page 353-355, and page 362 wherein Okutomi teaches that the summation of the sum of squared differences (SSD) from multiple stereo pairs can be used to indicate the “correctness” of a set of matching points. The Examiner states that this summation is analogous to a matching cost in that it approaches a minimum for correct matches. Okutomi teaches the computation is made within a predetermined window W belonging to each of the stereo images.

In contrast, the present invention, as recited for amended Claim 1 from which Claims 10-11 depend from by way of an intervening claim, recites among other things that “each image represents one of the at least three views of the scene that are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other”.

Okutomi does not teach or suggest that each image represents one of the at least three views of the scene that are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other. In fact, Okutomi explicitly teaches that different baselines are generated by a lateral displacement of a camera. See for example the

Abstract. Therefore, Okutomi does not teach or suggest the presently claimed invention as now recited by amended Claim 1 and by dependent Claims 10-11.

Lewis teaches how unnormalized cross correlation can be efficiently normalized using precomputing integrals of the image and image² over the search window. However, nowhere does Lewis teach detecting a plurality of pixels in a base image that represents a first view of a scene, wherein the first view is one of at least three views of a scene; determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in a plurality of images, each image representing one of the at least three views of the scene, wherein each of the at least three views of the scene are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other; and tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the plurality of images to create the virtual piecewise continuous depth surface viewed from the base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image, as recited for amended Claim 1 from which Claims 10-11 depend.

Accordingly, in view of the amendments and remarks above, since neither Chen [VSMM99], Okutomi, Lewis, nor any combination thereof, teaches, anticipates, or suggests, the presently claimed invention as recited for Claims 10-11, Applicant believes that the rejection of Claim 10-11 under 35 U.S.C. 103(a) has been overcome. The Examiner should withdraw the rejection of these claims.

Allowable/Allowed Subject Matter

(46-47) The Examiner stated that Claim 29 would be allowable if rewritten or amended to overcome the rejeciton(s) under 35 U.S.C. 112, first paragraph, set forth above.

As discussed above in section **(2)**, Applicant has amended Claim 29 to overcome the 35

U.S.C. 112, first paragraph rejection, and Applicant believes that Claim 29 now recites in allowable form. Applicant kindly requests that the Examiner allow Claim 29.

Citation of Relevant Prior Art

(48-49) Applicant has reviewed the prior art made of record and believes that each of the cited references alone or in any combination, and including any combination with Chen [VSMM9], Zhang, Okutomi, and/or Lewis, does not teach, anticipate, or suggest, the presently claimed invention.

Conclusion

The foregoing is submitted as full and complete response to the Official Action mailed October 7, 2004, and it is submitted that Claims 1-29 are in condition for allowance. Reconsideration of the rejection is requested. Allowance of Claims 1-29 is earnestly solicited.

No amendment made was related to the statutory requirements of patentability unless expressly stated herein. No amendment made was for the purpose of narrowing the scope of any claim, unless Applicant has argued herein that such amendment was made to distinguish over a particular reference or combination of references.

Applicant acknowledges the continuing duty of candor and good faith to disclosure of information known to be material to the examination of this application. In accordance with 37 CFR §§ 1.56, all such information is dutifully made of record. The foreseeable equivalents of any territory surrendered by amendment are limited to the territory taught by the information of record. No other territory afforded by the doctrine of equivalents is knowingly surrendered and everything else is unforeseeable at the time of this amendment by the Applicant and the attorneys.

The present application, after entry of this amendment, comprises twenty-nine (29) claims, including four (4) independent claims. Applicant has previously paid for twenty-nine (29) claims including four (4) independent claims. Applicant, therefore, believes that a fee for claims amendment is currently not due.

However, a petition for extension of time to file this Response has been attached. The Commissioner is authorized to charge the extension fee for response within the first month of **\$120**, or if this fee amount is insufficient or incorrect, then the Commissioner is authorized to charge the appropriate fee amount to prevent this application from becoming abandoned to Deposit Account **50-1556**.

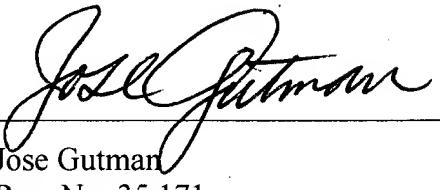
If the Examiner believes that there are any informalities that can be corrected by Examiner's amendment, or that in any way it would help expedite the prosecution of the patent application, a telephone call to the undersigned at (561) 989-9811 is respectfully solicited.

The Commissioner is hereby authorized to charge any fees that may be required or credit any overpayment to Deposit Account **50-1556**.

In view of the preceding discussion, it is submitted that the claims are in condition for allowance. Reconsideration and re-examination is requested.

Respectfully submitted,

Date: 2/7/05

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IN THE DRAWING:

Please replace all of the sheets of the Drawing figures with the 12 sheets identified at the top margin as "Replacement Sheet" and that are attached to this Amendment. These twelve (12) replacement sheets provide formal drawings conforming to the originally filed drawing figures. No new matter was added.